Batteries 2013

Stationary batteries

An overview of realized systems, actual market situation and future trends

October 14th, 2013 | Dr. Peter Stenzel

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Outline

- Introduction
- Batteries for grid services / primary control
- Batteries in PV home storage systems
- Summary and future trends

Introduction

Classification of stationary battery applications

1) Grid services


Source: Vattenfall

- Li-Ion (2013): 2 MW / 2.56 MWh
- Grid services (primary- and secondary control)
- Berlin/Germany

2) Batteries in smart grids


Source: Stadtwerke Trier

- RFB (2013): 10 kW / 100 kWh
- Combination with PV for electric vehicle charging station supply
- Trier/Germany

3) Renewable integration

- Li-Ion (announced 2013): 6 MW / 10 MWh
- Substation and distribution network investment deferral (Leighton Buzzard/UK)

- NaS (announced 2013): 35 MW / 245 MWh
- RES curtailment reduction and tertiary reserve (Southern Italy)

4) PV home storage systems


Source: Varta


Source: CentroSolar


Source: FIAMM

Typical size: 1-20 kWh (modular)

- Broad variety of applications (kWh to MWh scale)
- Considerably increase of new battery project announcements
- Involved technologies: Li-Ion, NaS, Redox-Flow, Lead acid, $NaNiCl_2$

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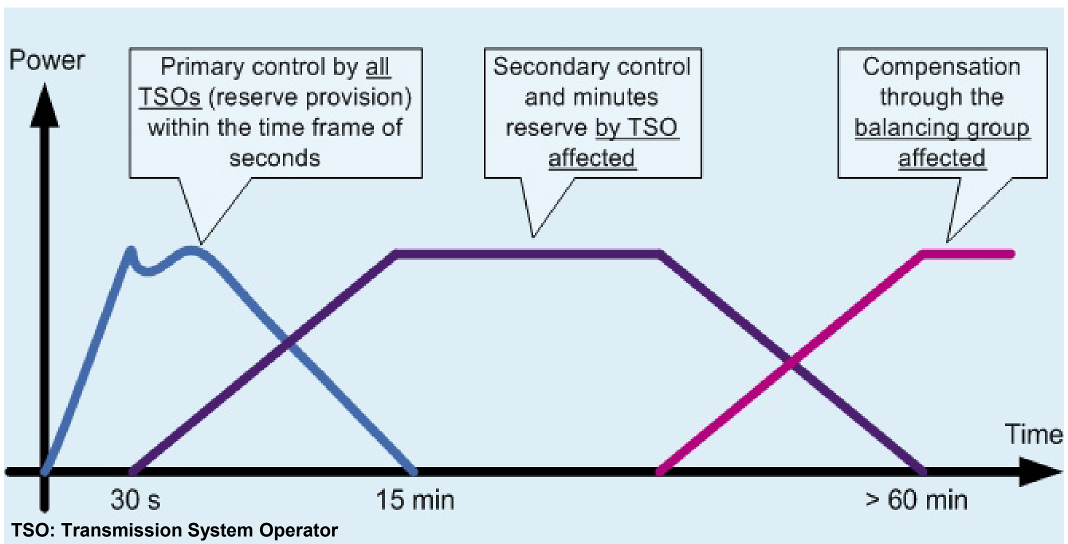
Background reserve / control power

- Reserve or control power is required to balance supply and demand at all times
- Control power demand results from non predictable deviation between the scheduled and the actual grid situation (e.g. due to forecast error)

Classification of the control market in Germany



Source: regelleistung.net

Primary control (fast reserve)

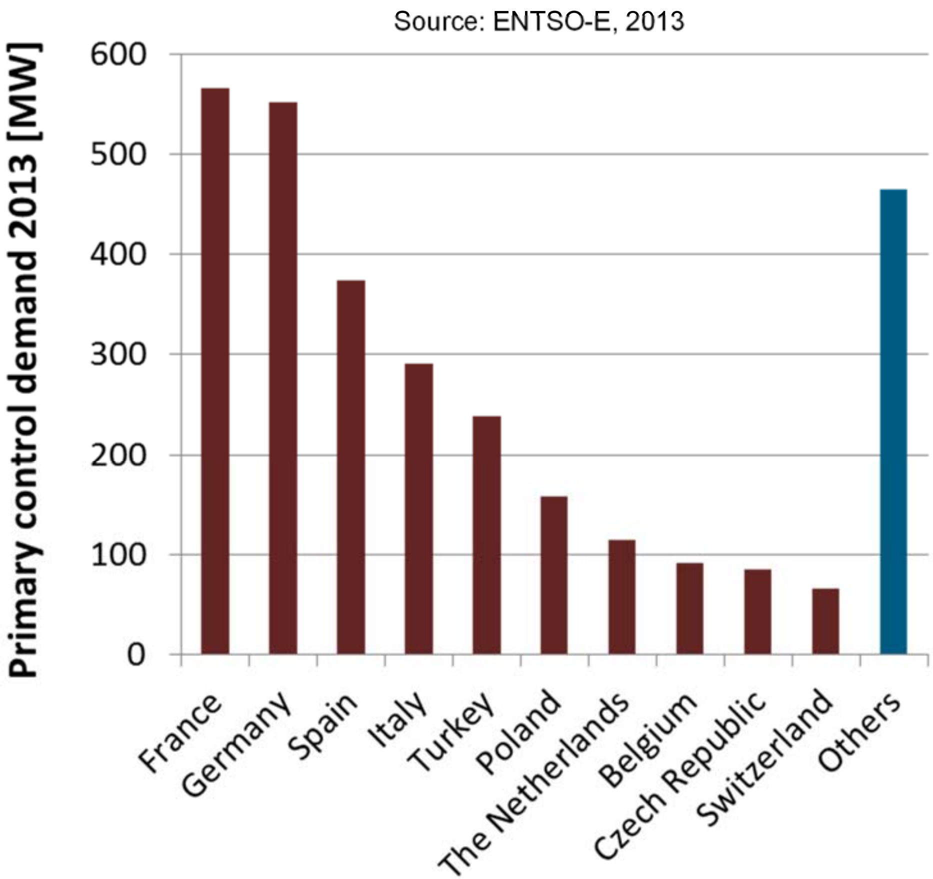
- Minimum size: +/- 1 MW
- Activation time: completely in between 30 s
- Duration: 0 < t < 15 min
- Payment: capacity price only; independent from utilization

➡ **Focus for Batteries: primary control** (highest dynamics, limited operation time)

Market size – primary control

- Total primary control demand in ENTSO-E Region Continental Europe: 3,000 MW (fixed market size; depending on regulatory framework)

- Country distribution according to net electricity generation share from total generation



Actual situation:

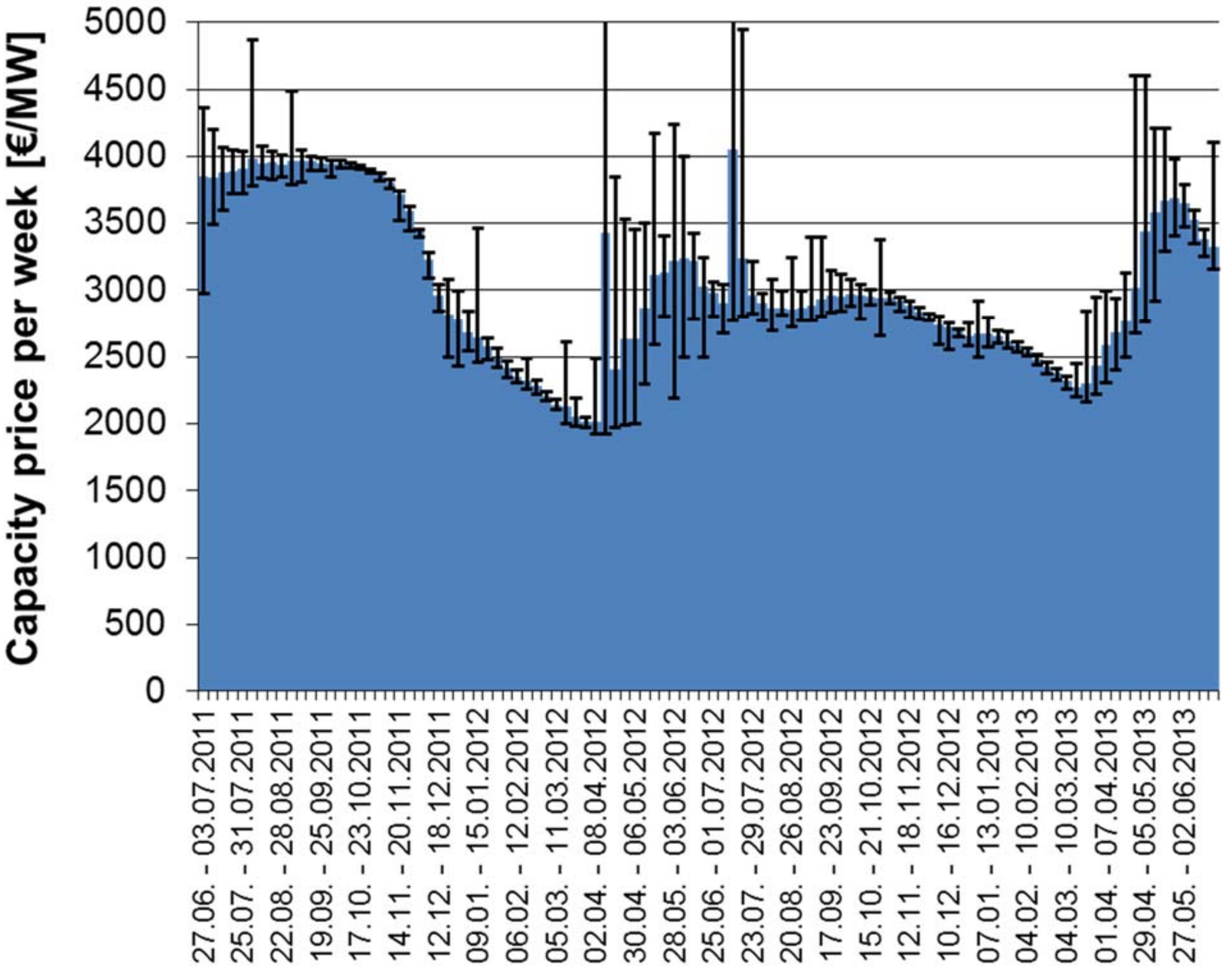
- Control power provision mainly by conventional power plants

Alternatives:

- Demand side management
- Control power provision by renewable energies
- Batteries
- Other storage technologies

Calculation of break-even CAPEX

Capacity price development for primary control in Germany



Source: regelleistung.net

Calculation of break-even CAPEX for new battery systems:

Mean specific capacity price payment per year: ≈ 165,000 €/MW

Interest rate: 5 %

Operation costs: 2 %/a from CAPEX

Amortization period: 10 a

Energy/Power ratio: 1:1

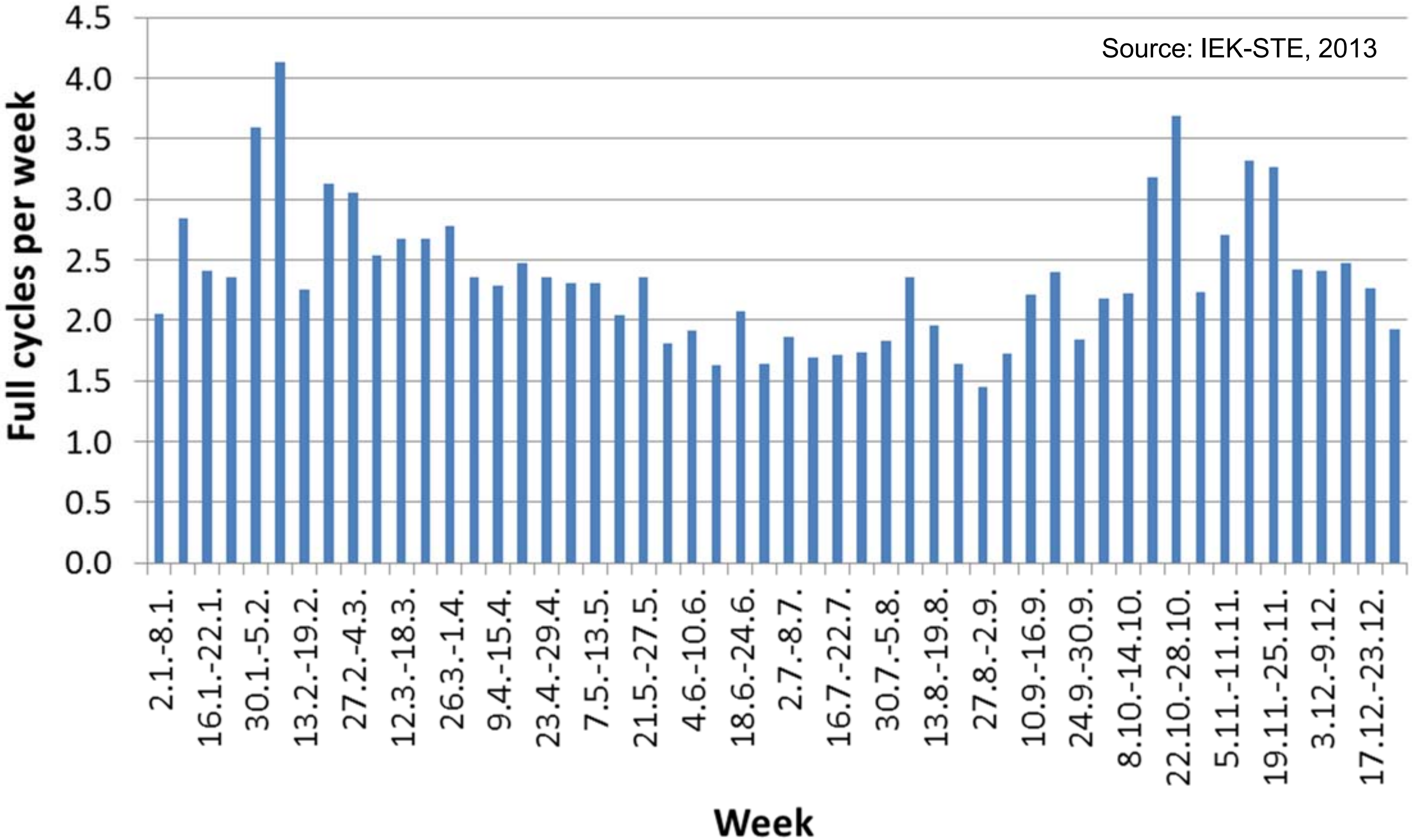
⬇

max. CAPEX:
≈ 1,100 €/kWh

1 MW / 1 MWh Battery
≈ 1.1 Mio. €

Analysis of battery requirements

Simulated battery operation for primary control provision during 2012



Battery size:
1 MW / 1 MWh
(DoD: 100 %)

Mean cycles per week: 2.36

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Full cycles per year: 123

Operating modes (mean values per week):
- 4,625 discharge operations
- 4,018 charge operations

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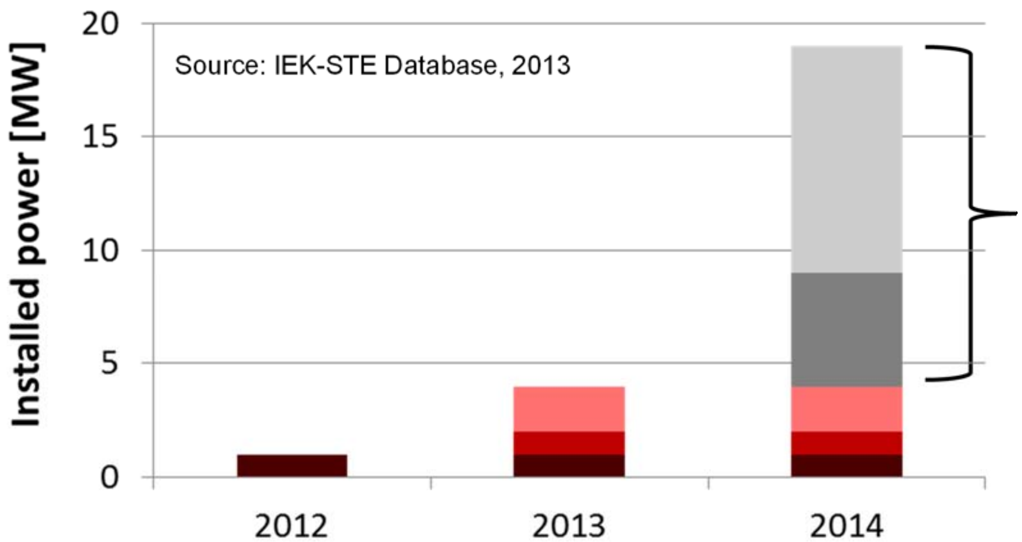
- Large number of small cycles
- Additional balancing power required for SOC regulation

Market development – primary control

Development of installed battery capacity in Germany for primary control provision



- 2 projected Li-Ion systems (5 MW and 10 MW)
- Scheduled commissioning end of 2014

- Technologies: 4 x Li-Ion, 1 x NaS
- Installed capacity: 19.24 MWh

➡ Capacity to power ratio: ≈ 1:1

- Market share Germany 2014: approx. 3.5 % from total market (551 MW)

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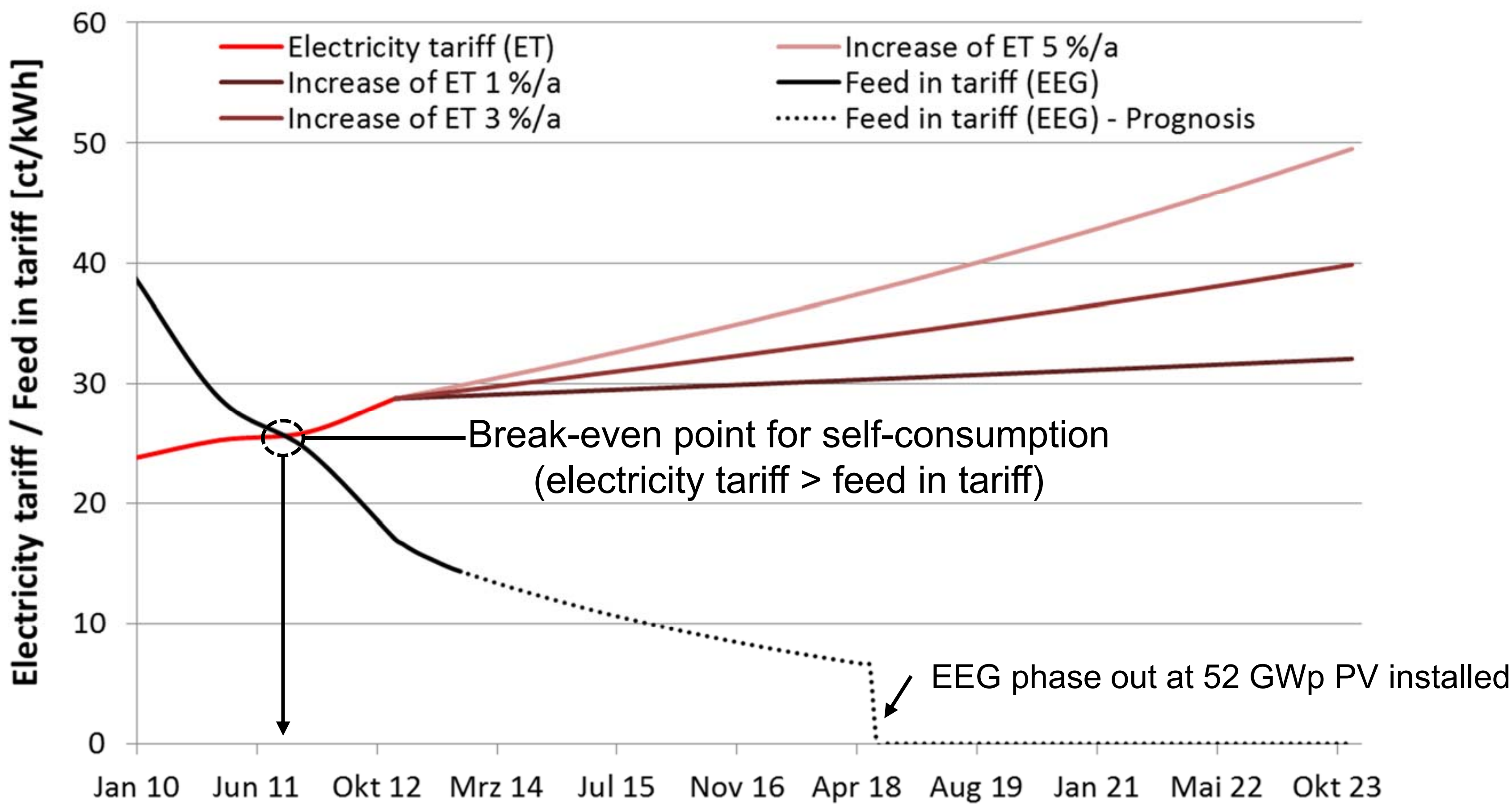
Motivation for PV power self-consumption

Self-consumption: Direct use of local produced PV electricity without grid feed in

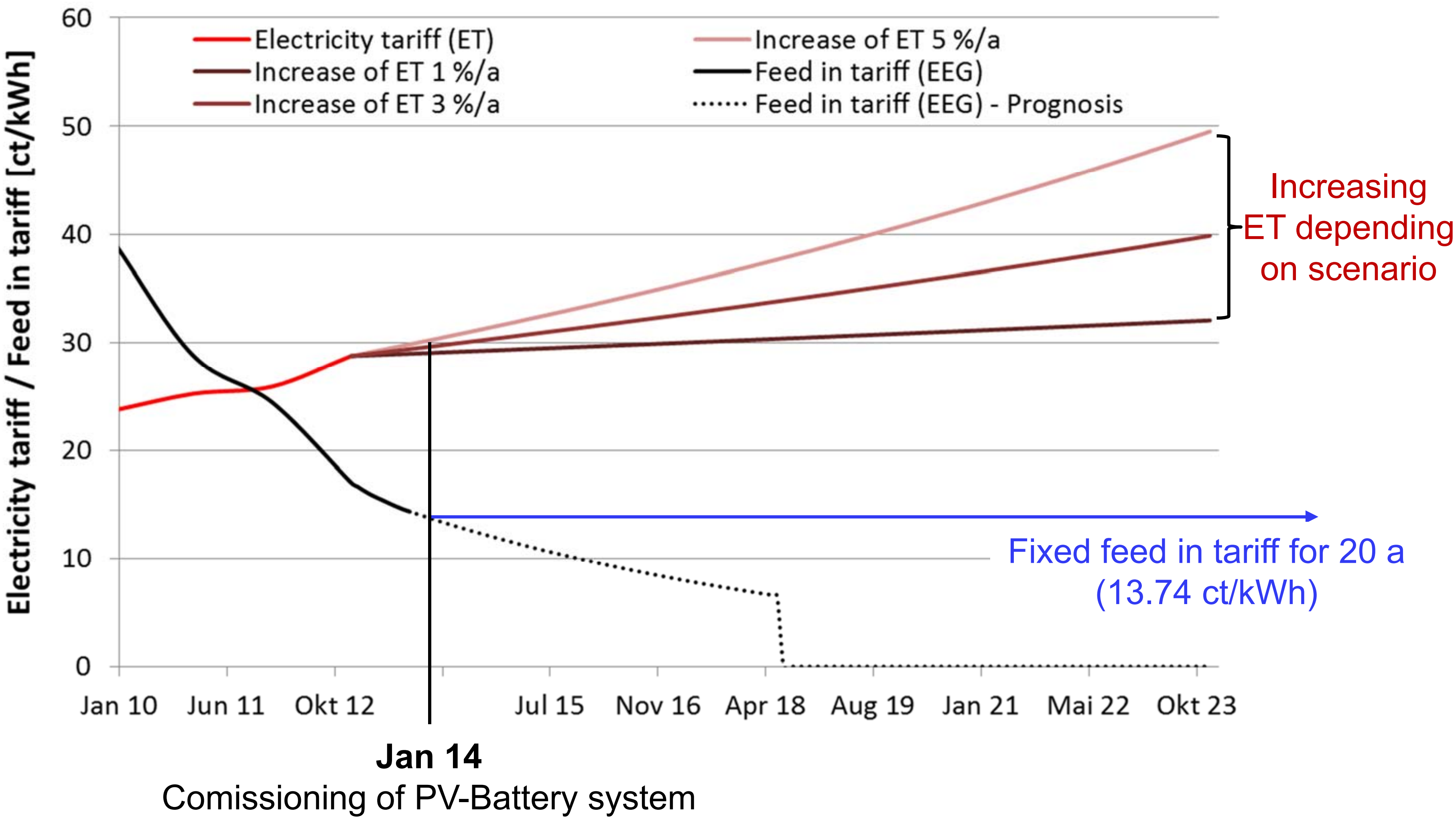


Basis data: Electricity tariff for households and feed in tariff (EEG) from Germany

Source: IEK-STE, 2013 based on BDEW, 2013 and BNetzA, 2013

Calculation of break even storage costs

Margin for batteries: Difference between feed in tariff and electricity tariff



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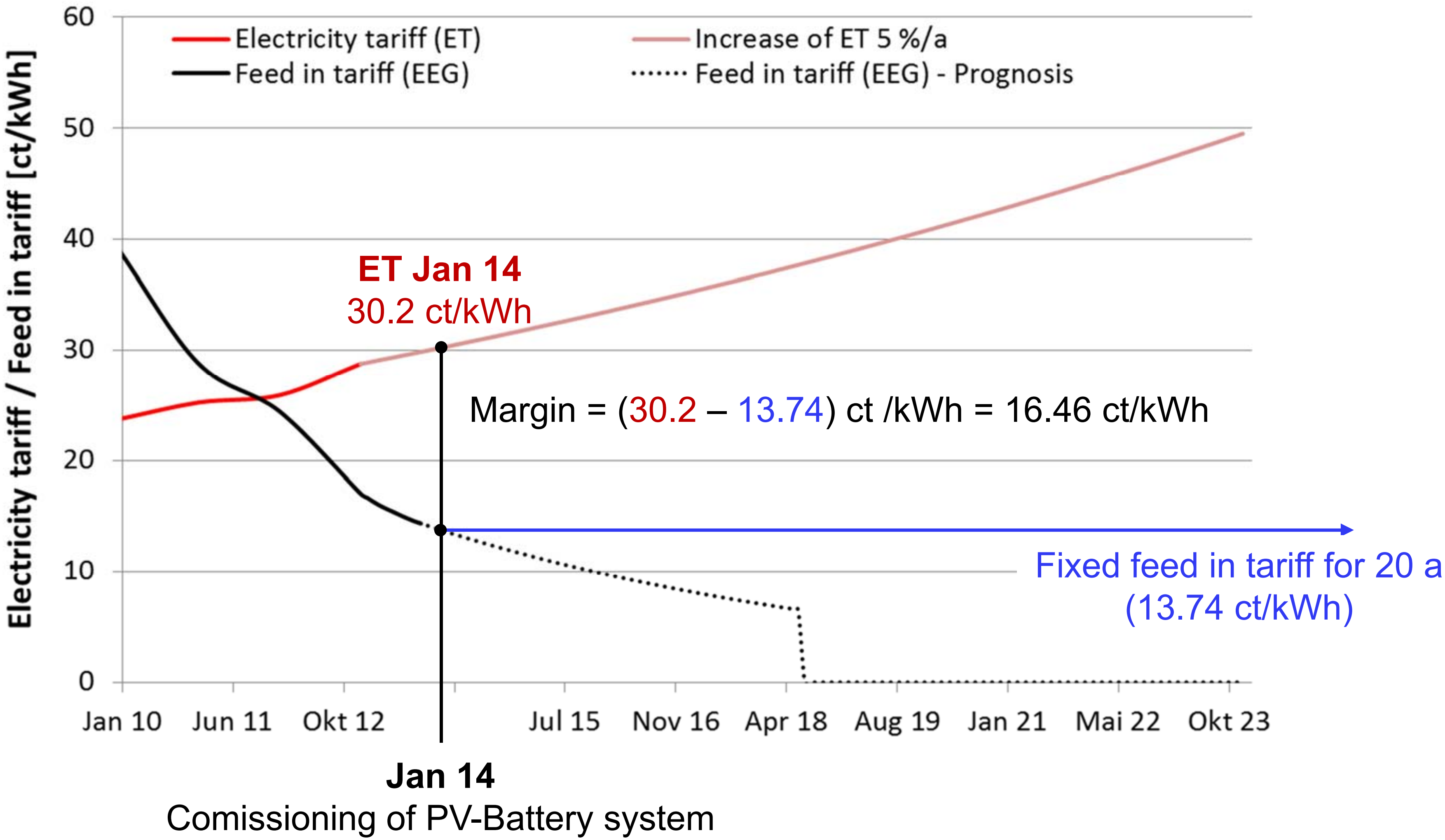

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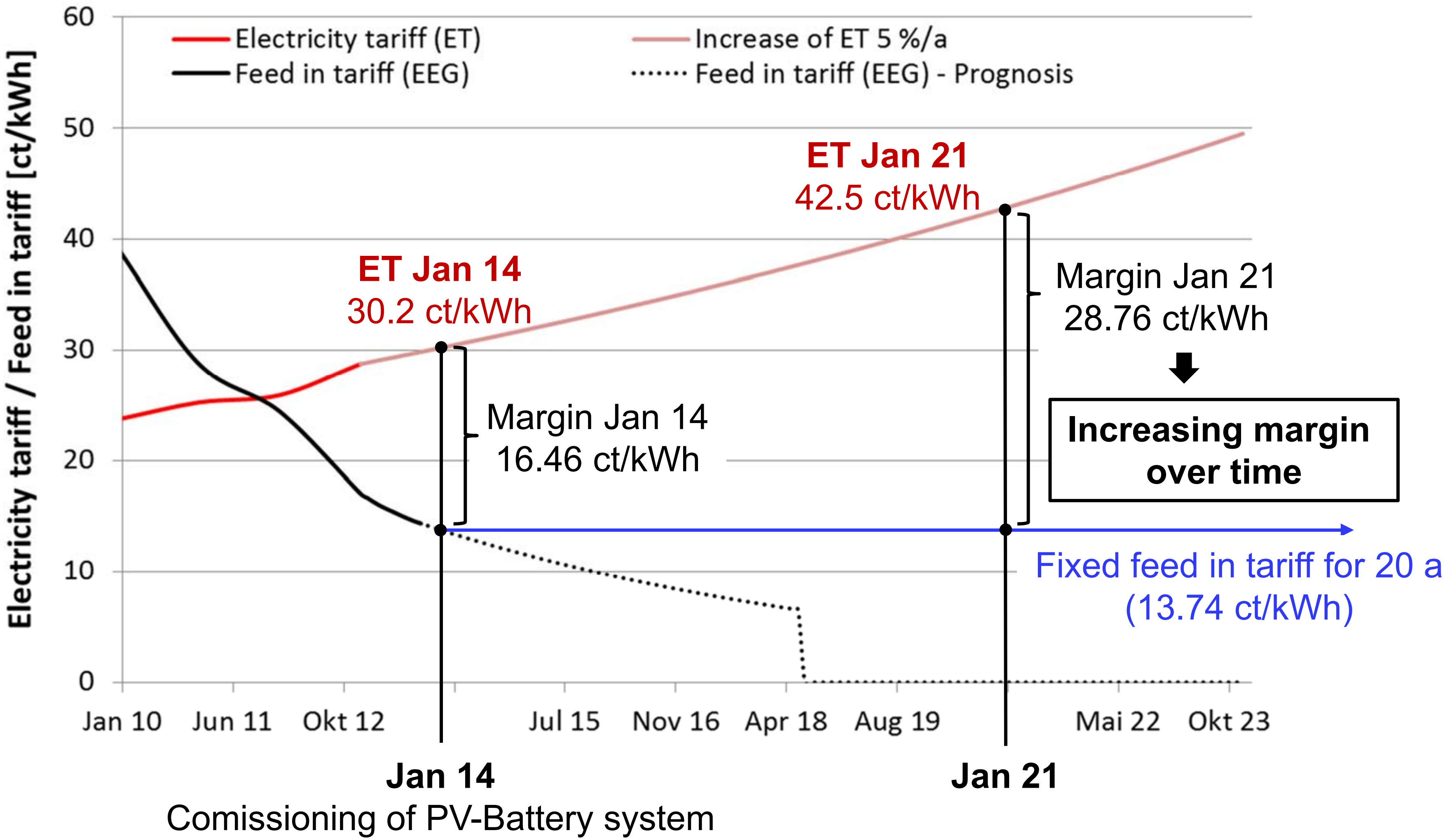

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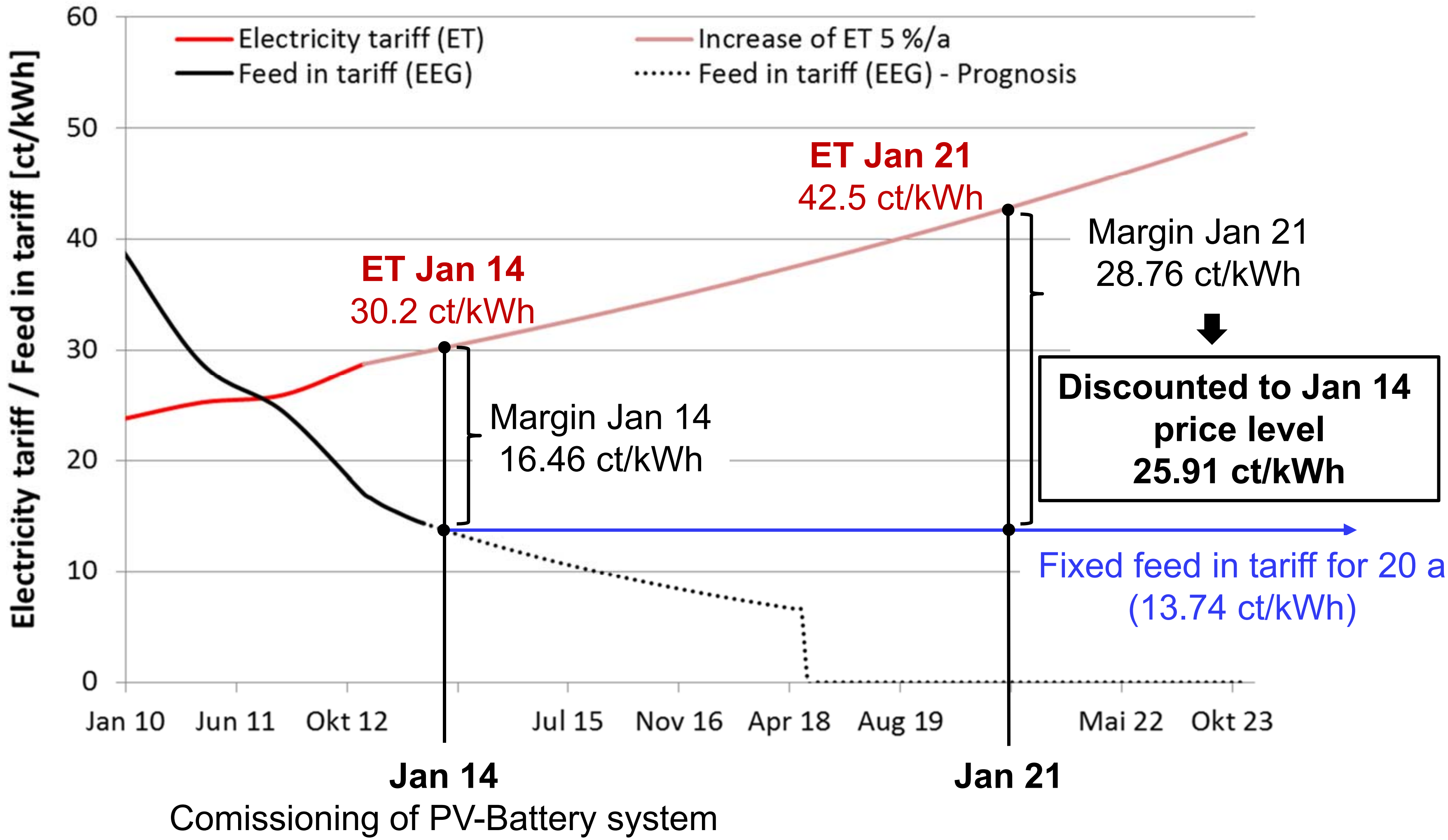
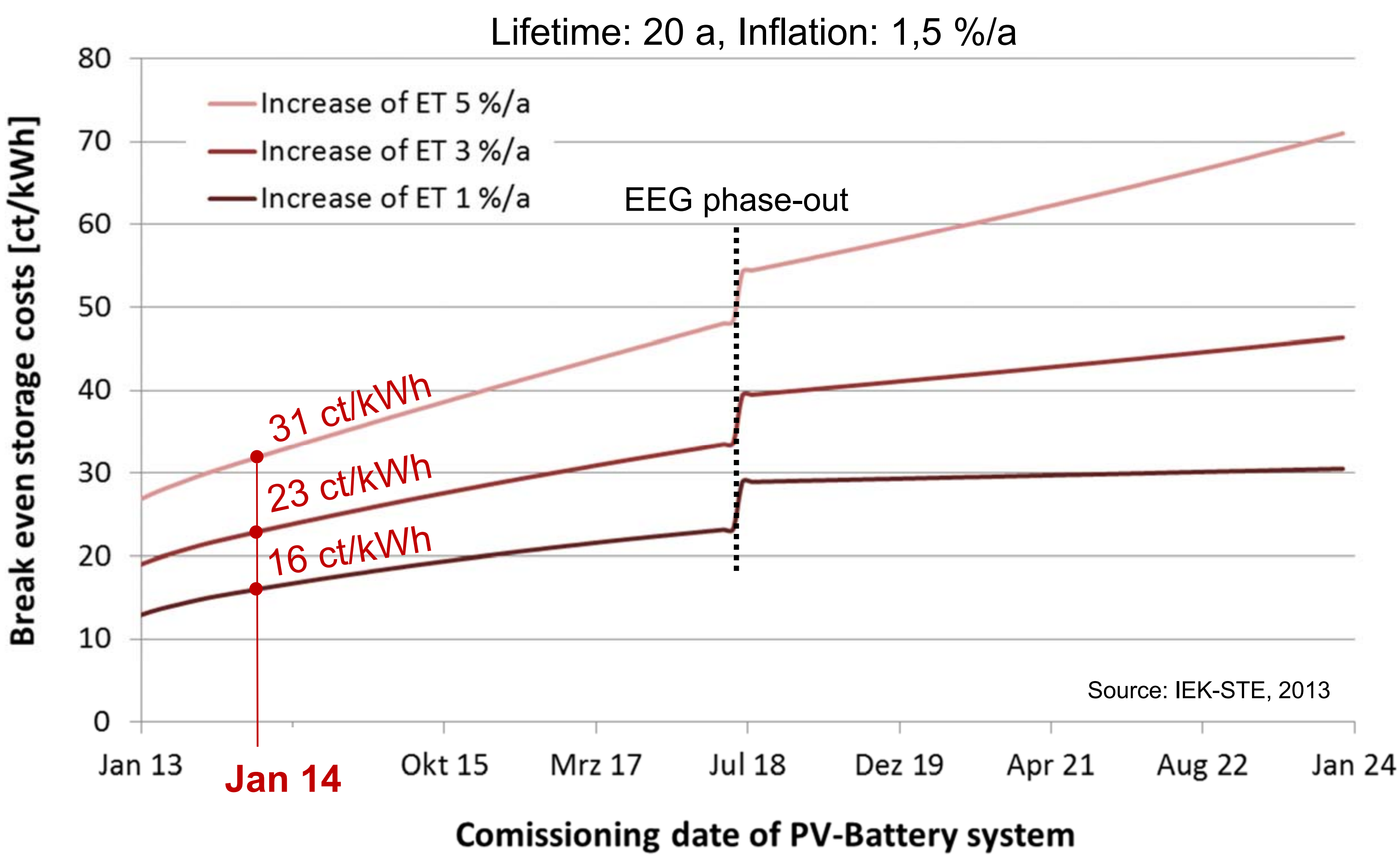


Results: break even storage costs

Break even storage costs: arithmetic mean of the yearly difference between feed in tariff and electricity tariff over 20 a (discounted to system comissioning year)



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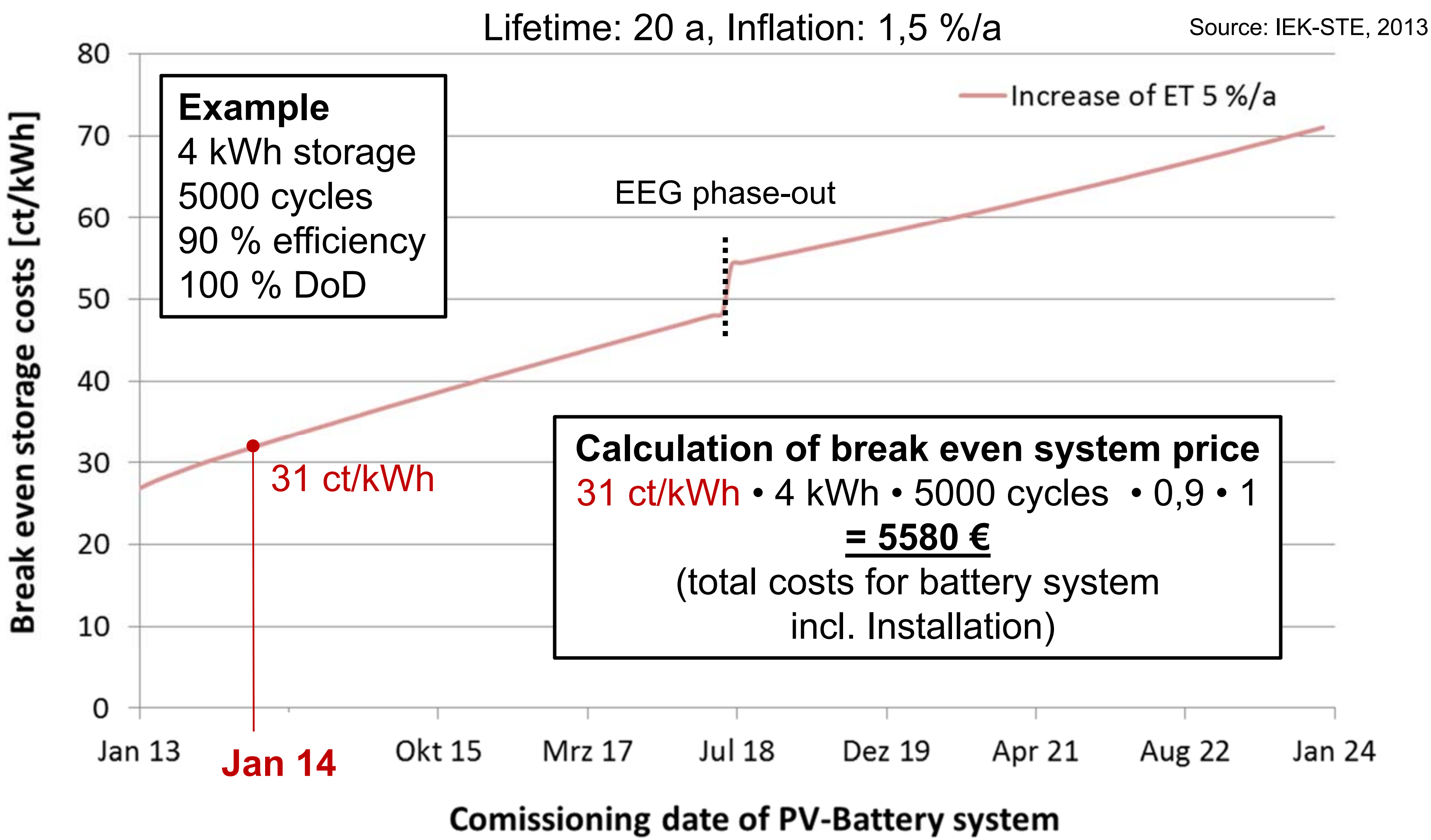


Calculation of storage costs

Aim: comparison of break even storage costs with actual system cost level

Definition: specific costs per kWh net energy from the battery

$$\text{Storage costs} = \frac{\text{Battery system costs (incl. installation) [€]}}{\text{Battery capacity [kWh]} \cdot \text{DoD [\%]} \cdot \text{Cycles} \cdot \text{Storage efficiency [\%]}}$$

Basis data:

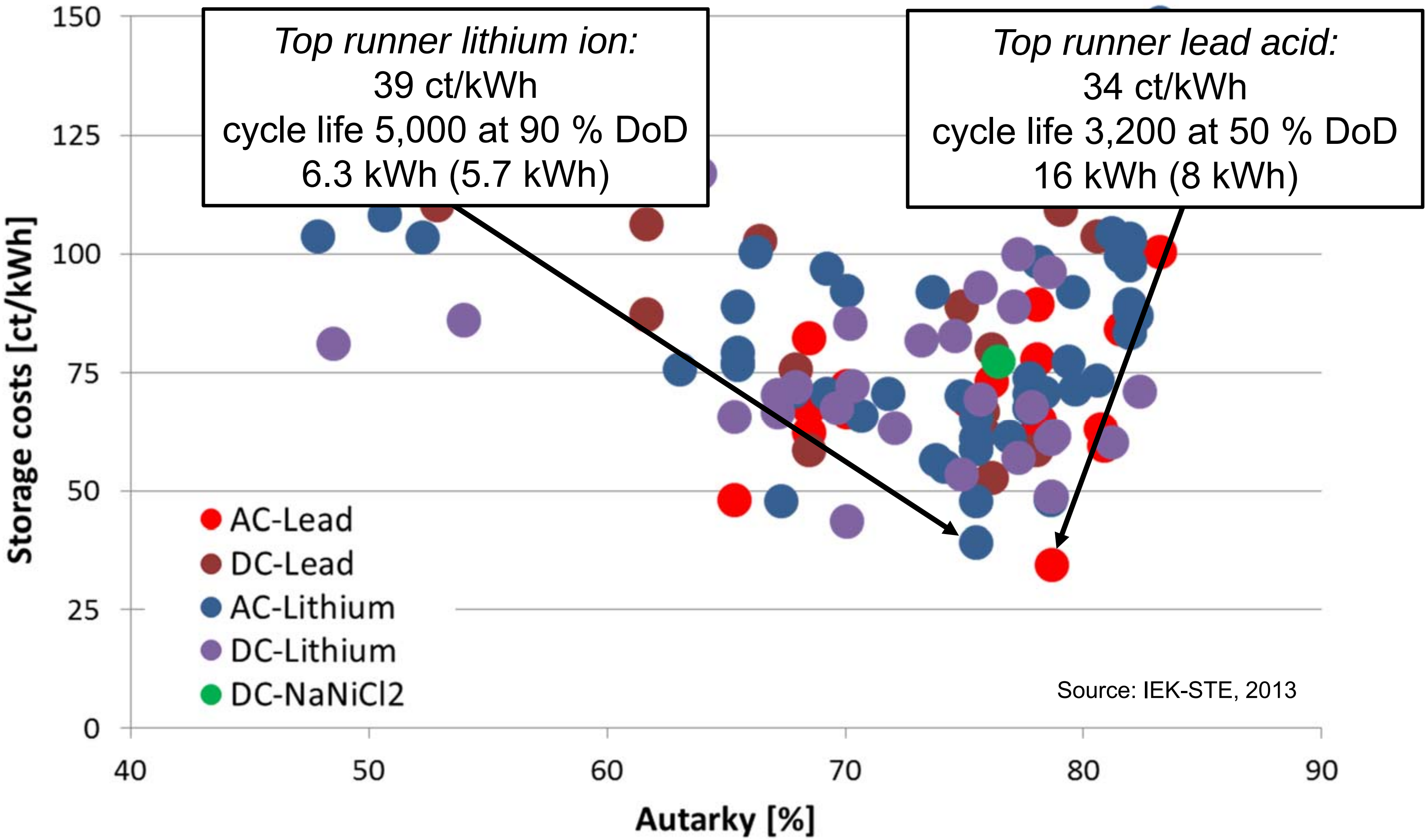
- Battery system storage database
  (128 systems from 40 providers; data from August 2013)

Boundary conditions:

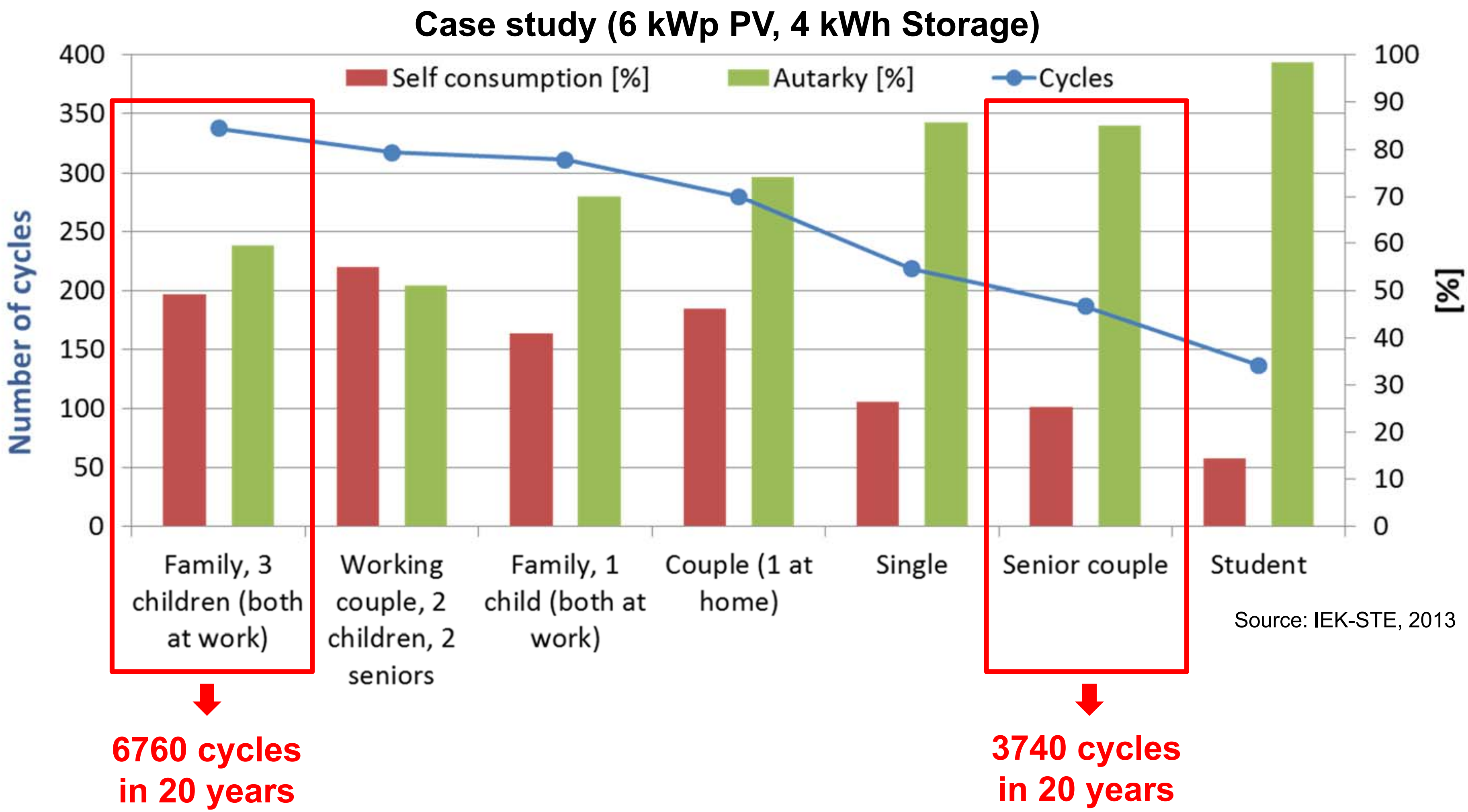
- Total system lifetime 20 a (PV + battery + power electronics)
- Battery cycles are calculated considering the load profile (**PV-Battery system model**)
- Battery replacement considered (if required)

Results: storage costs

Case study: Family with 1 child, both parents at work, PV production profile (6 kWp) from central germany



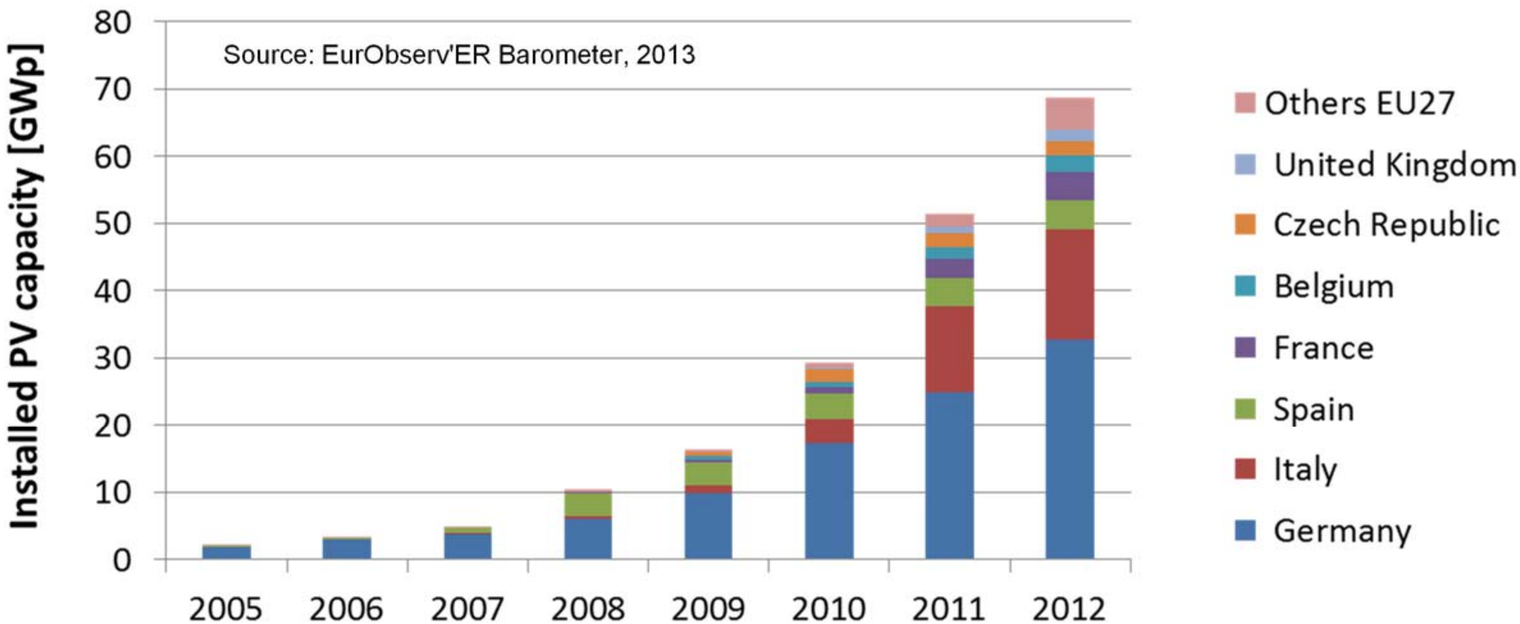
Impact of different load profiles



Source: IEK-STE, 2013

- Different battery solutions for (cost) optimal system configurations
- Consideration of demand side for battery selection recommanded

Market size – existing PV installations



- Storage becomes economic interesting after phase-out of the feed in tariff (15-30 years after installation)

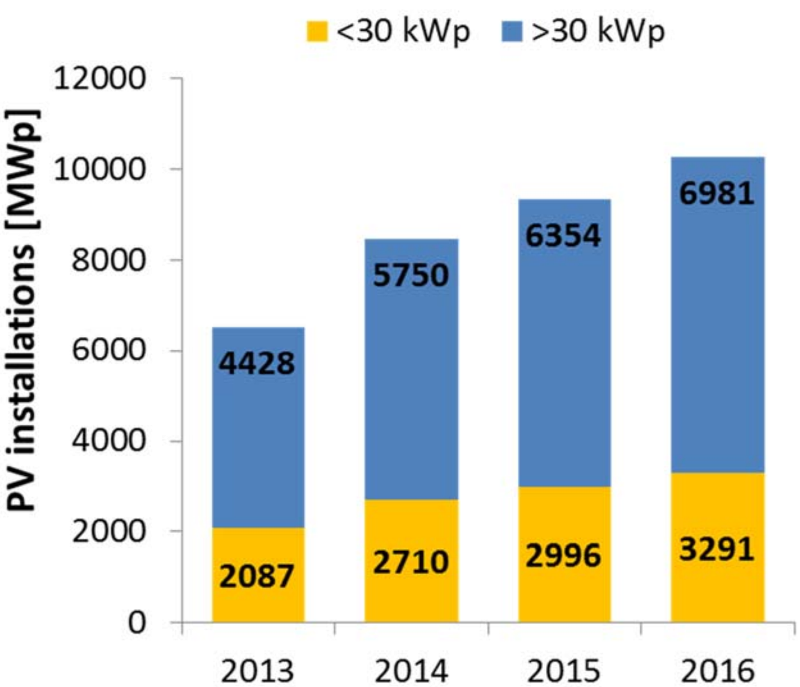
  ➡ Relevant market size from 2025 on

- Constraints: uncertainty about additional PV-lifetime 20+

➡ Short/medium term focus for PV-Battery systems mainly for <u>new</u> PV installations

Market size – new PV installations

EPIA moderate PV market scenario for EU27



Source: EPIA, 2013

Assumptions for PV-Battery market scenario

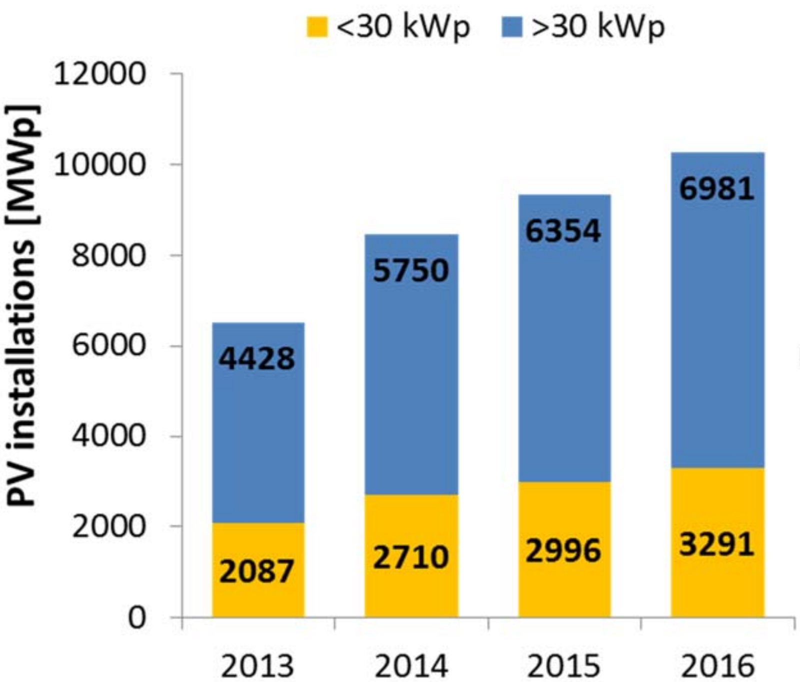
- Majority of battery systems in market segment <30 kWp
(basis for battery scenario)

- Share of market segment <30 kWp from total market 32 %
(basis: German market 1H 2013)

- Ratio between installed battery capacity and installed PV capacity 1:1 kWh/kWp
(useable capacity depends on battery type and DoD)

Market size – new PV installations

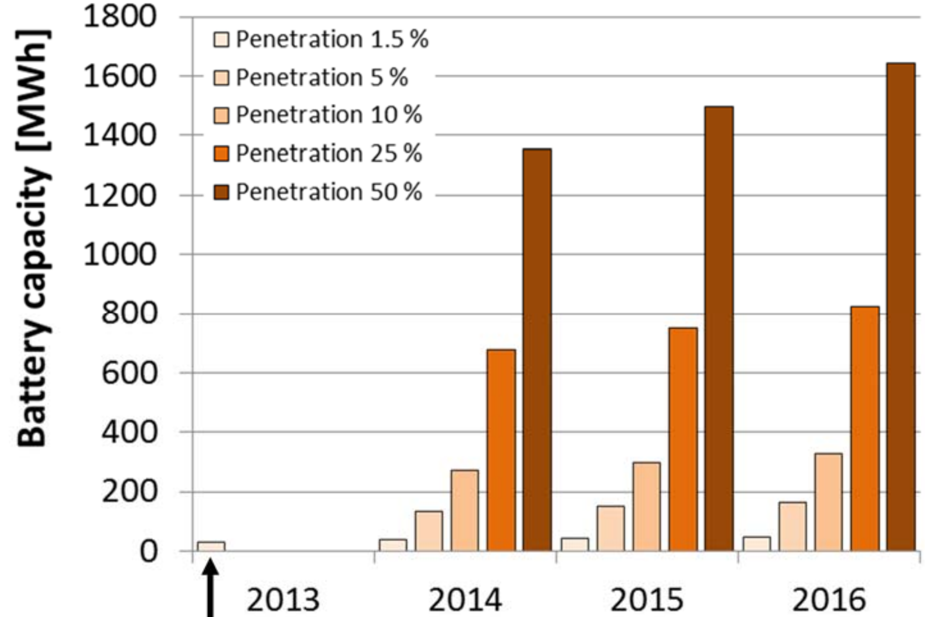
EPIA moderate PV market scenario for EU27



Source: EPIA, 2013

Battery market scenario for EU27 according to PV market development

Source: IEK-STE, 2013



Actual market penetration (Germany): ≈ 1.5 %

(basis: New installed PV-Battery systems in Germany May-August 2013, with KfW incentive program)

➡ Total PV-Battery market EU27 in 2013: 31 MWh (Germany: 19 MWh)

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Summary

Batteries for primary control provison

- Technical requirements of primary control provision are well suited for batteries
- Actual price level (in Germany) seems to allow a profitable operation of batteries
- Fixed market size; active competition with alternative technologies
- Uncertainty of future price and market framework development

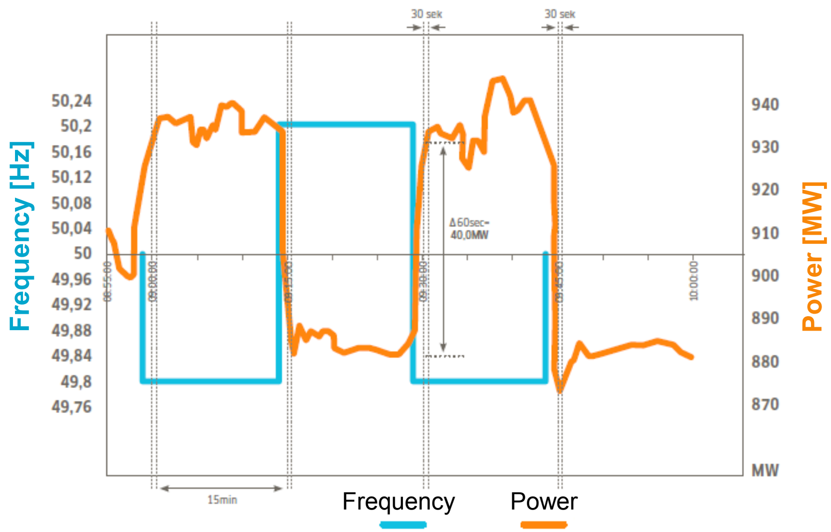
Batteries in PV home storage systems

- Expected to be a fast growing market segment in combination with new PV installations
- Consideration of demand side for system design and battery selection recommanded
- Cost-effectiveness is highly dependent on future electricity tariff development
- Wish for autarky is an important market driver

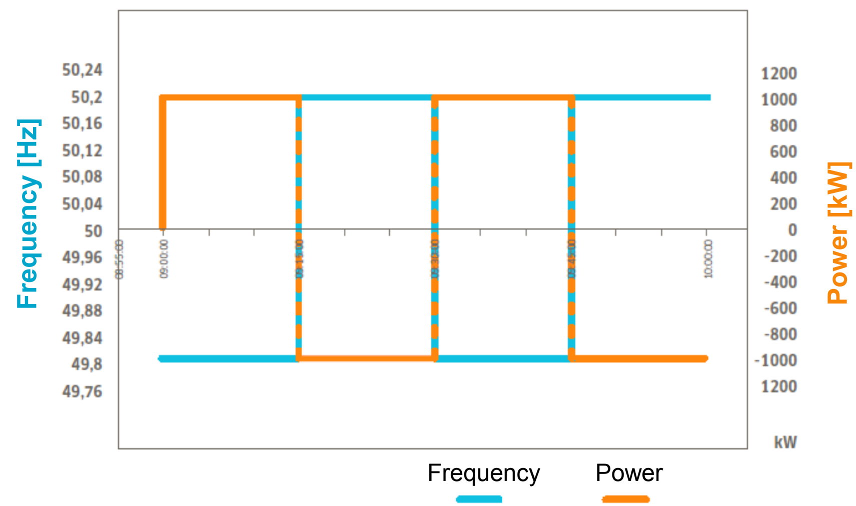
Additional slides

Advantages of batteries for primary control provision

pre-qualification test fossil power plant



pre-qualification test battery

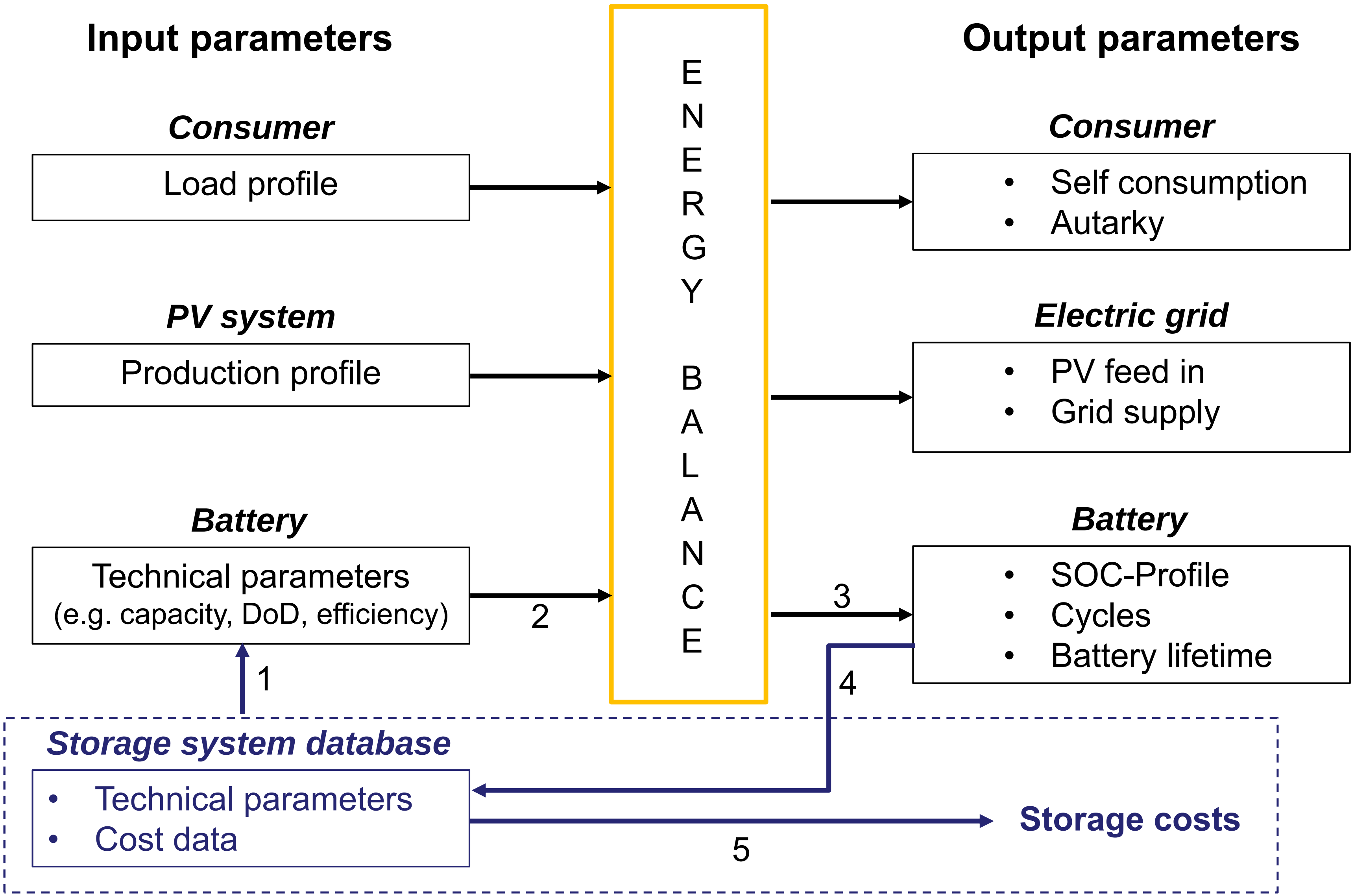


Source: Younicos, 2012

- Much higher dynamics and precise reaction to frequency deviations
- No must-run capacity required (interesting for high RE systems)
- Provision of positive (discharge mode) and negative control (charge mode) possible
- High (storage) efficiency (> 90 % AC-AC)

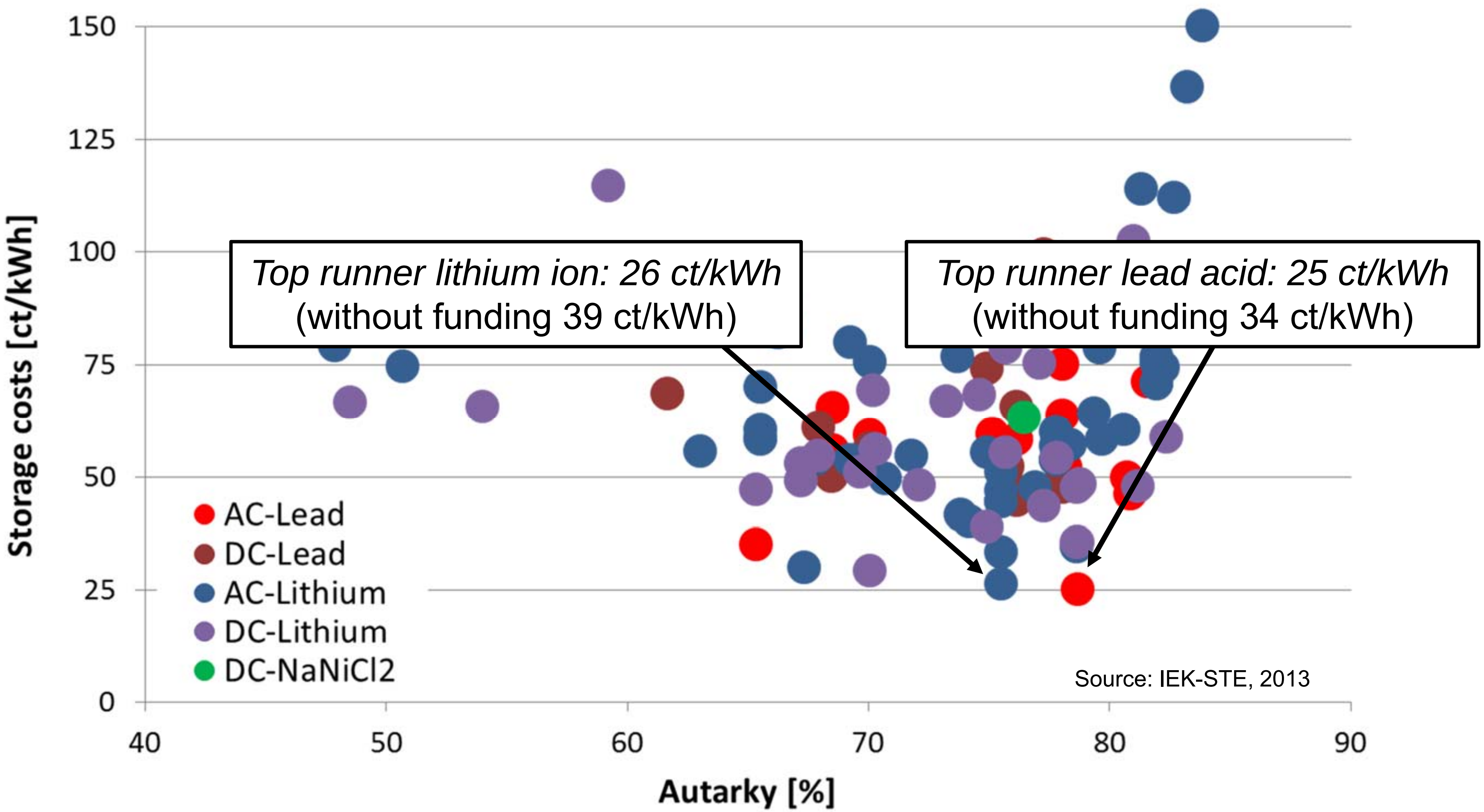
Additional slides

PV-Battery system model



Additional slides

Storage costs for 6 kWp PV-System, Family with 1 child inclusive governmental funding (discounted credit rate + grant - KfW program 275)



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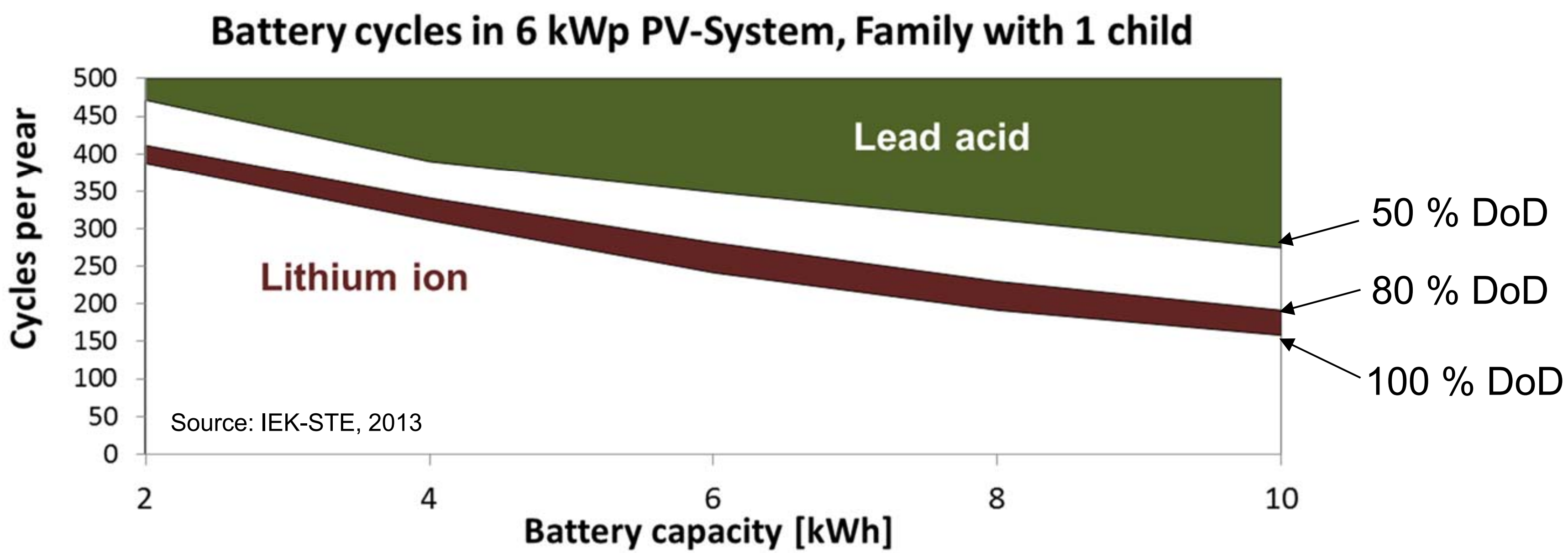

Lead acid

Cycles in 20 years: 5,500 - 9,420

Lithium ion

Cycles in 20 years: 3,160 - 8,220

Data of available PV storage systems

Max. DoD 50 %
Cycle life 2,500 - 3,000

➡ Battery life 5 - 11 a

Max. DoD 80 - 100 %
Cycle life 5,000 - 15,000

➡ Battery life 12 - >20 a